Space Weather Technical Forecast

Issued on Tuesday, 07 February 2023 at 00:52 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Risk of G1/Minor Storm intervals decreasing slightly as X-ray flare chances rise.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the past 24 hours, with the past UTC day characterised by two distinct behaviours at GOES16 - a flat trace near the B/C flux boundary prior to midday, and occasional mostly low-level C-class flares thereafter. This arose as AR3211 and 3212 flared against a backdrop of general decay (with AR3211 producing the peak flare of a C7.8 at 06/1212UTC); while in the northeast significant growth occurred in AR3213 and 3214 with concurrent flare activity as a result.

The number of sunspot regions increased through the UTC day, with up to nine recorded. As stated, the main changes were seen in the northeast, with AR3214 emerging from plage to become the nominally most complex spot by the period's end as a Dao/Beta. On its heels was AR3213, which grew to become a Dri/Beta to its north.

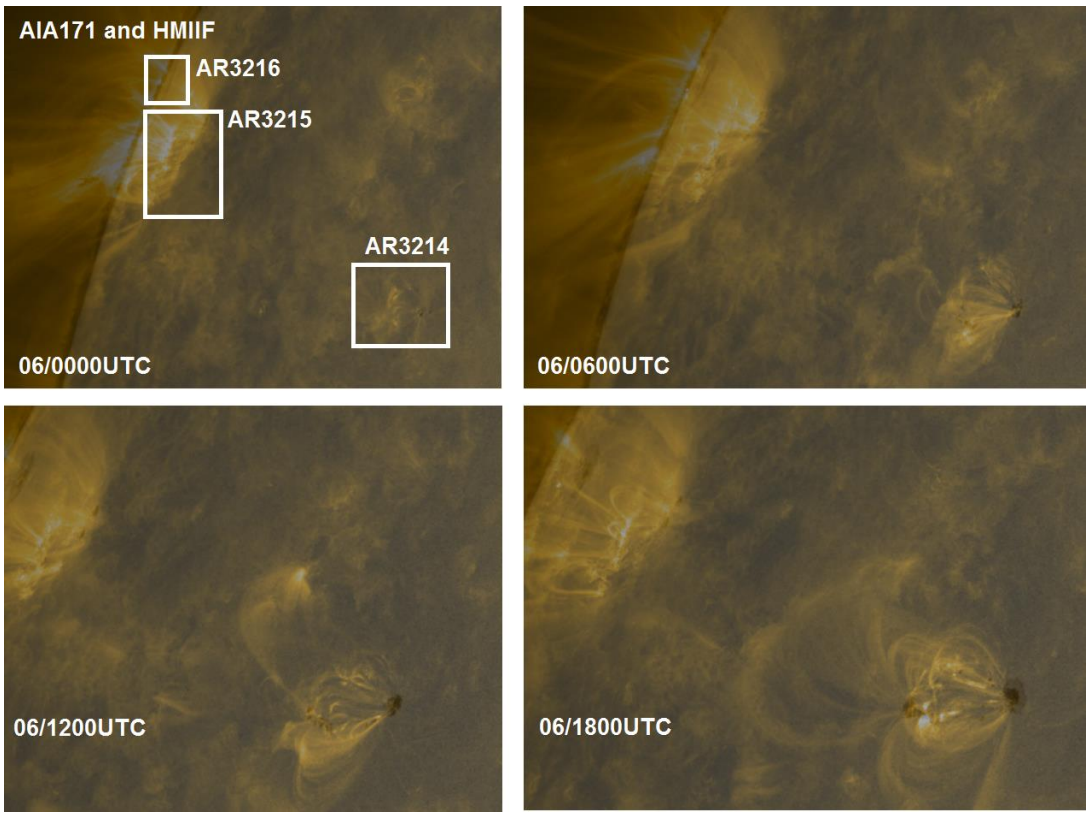

Figure 0: AIA171 and HMIIF composite (using Helioviewer.org) showing the rapid growth of AR3214 in the past 24 hours.

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The peak flare of the past 24 hours also produced a Coronal Mass Ejection (CME) that was seen heading largely south and west of the Sun-Earth line on coronagraph imagery, with this subsequently confirmed by modelling. Finally, while not mobile at the time of writing, a notably large 60 degree-spanning filament dominates the south central portion of the Sun at present. No Earth-directed CMEs were observed during the period.

Solar Wind / Geomagnetic Activity: Solar wind parameters, as observed by DSCOVR and ACE at L1, indicated a weak CIR-like signature into an awaited negative polarity fast wind in the period. This is thought to be that emanating from CH74/-, and the phi angle was accordingly mostly negative (towards the Sun).

The solar wind speed gradually rose from Background through Slightly Elevated to Elevated levels in the 24 hours - from near 375 to 500km/s. The solar wind density generally fell over the same interval as the CIR gave way to the coronal hole proper, with near 15ppcc falling to single figures ppcc with time, although switches between the primary observing satellites showed some detail differences. The IMF showed a slightly erratic magnitude in the period, peaking at 13nT, while the north-south component varied between +8 and -11nT.

The overall effect of the above solar wind measures was for Quiet to Active geomagnetic activity, with a provisional peak Kp of '4o' recorded in the 18-21UTC interval during a period of peak dB/dt and as the solar wind speed neared its maximum.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES16 remained at Background levels throughout.

The high energy electron flux (greater than 2MeV) measured by GOES16 was predominantly at Normal Background levels. The associated 24-hour electron fluence was well below the Active threshold on steady then falling trend, with the observed fluence at 07/0001UTC being 1.08e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low solar activity is likely to continue, however there are signs that the arriving eastern limb contains more potent active regions (from CME evidence, prominences and STEREO A EUVI 195 imagery), with a probable increase in activity therefore considered by midweek UTC, and thus an increasing Chance of M-class flares.

Solar Wind / Geomagnetic Activity: No definitively Earth-directed CMEs feature in the forecast at present, although given the sheer number of peripheral CMEs over the UTC weekend, confidence in this assertion is relatively low, especially from Day 2 (Wednesday 08 February). Non-impactful glancing transient activity is considered a possibility from midweek.

The current enhanced solar wind environment is expected to continue until midweek UTC, when effects from CH74/- and CH75/- are expected to wane in earnest. Unsettled to Active geomagnetic conditions, with a residual Slight Chance of G1 Minor Storm intervals, should reduce to predominantly Quiet levels from this time.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux observed by GOES16 is expected to remain at Background levels throughout, given the dearth of sunspot groups in the western solar hemisphere.

Background electron flux is likely to increase to Moderate or perhaps High levels from midweek (UTC), due to the fast wind environment, although the corresponding electron fluence perhaps only shows a Chance of exceeding the Active (1e8 integrated pfu) threshold in the forecast

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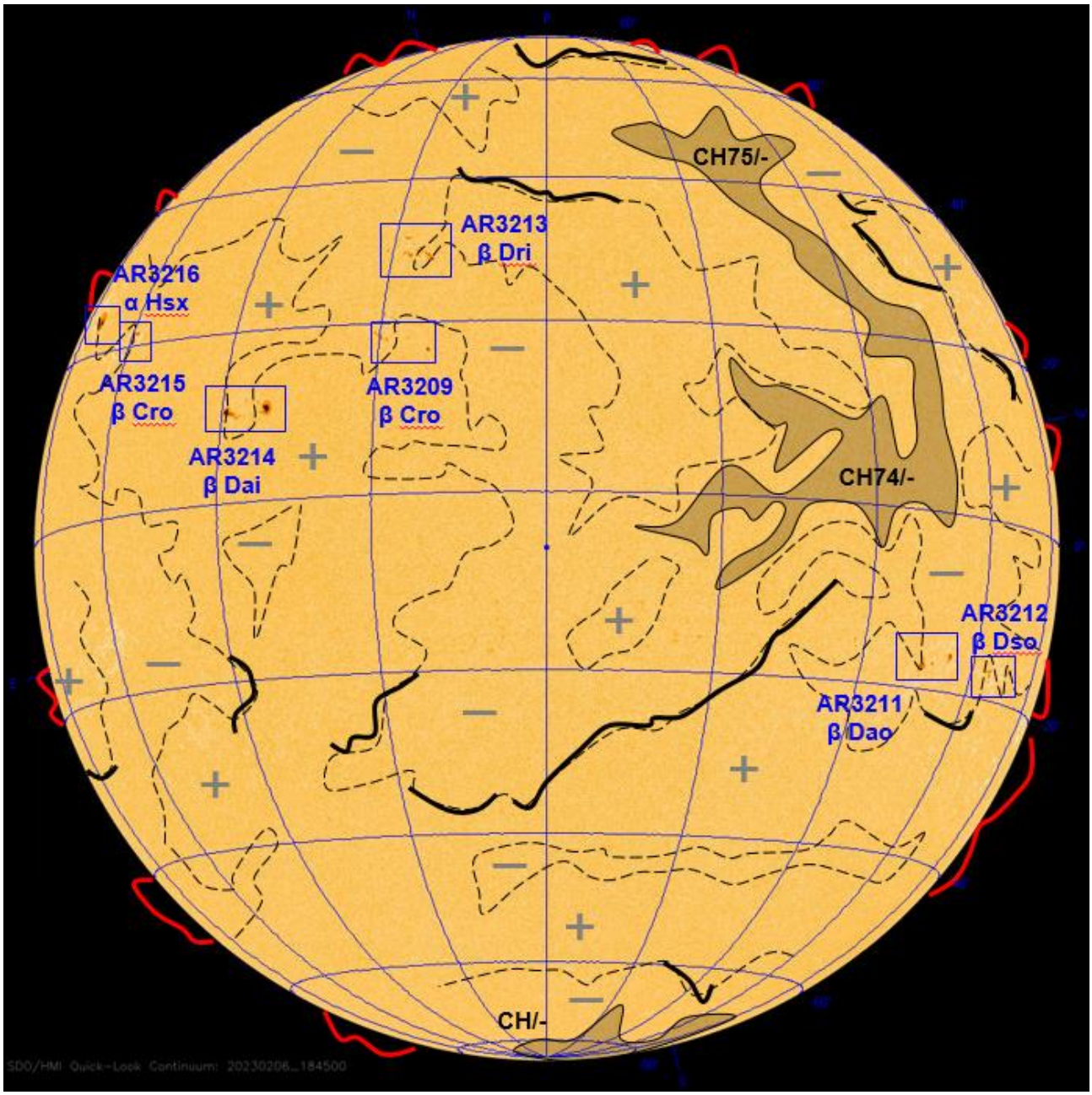
timeframe.

Figure 1. Solar Analysis Valid 06/1845UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are no definitively Earth-directed CMEs currently in the forecast. This being said, observed minor peripheral CMEs comfortably reached double figures over the past UTC weekend, and confidence in this assertion is therefore lower than typical. It is probable that non-impactful minor glancing CME incidence may occur later this working week, and attribution to any one event is likely to be very difficult. This is reflected in some of the MOSWOC Enlil ensemble members showing minor deviations from the unperturbed deterministic run on or after the second half of the current UTC day. This is felt to lie on the early end of any possible influence given Enlil's erroneous assumption that Earth has been transiting a 600-650km/s fast wind since the UTC weekend, when in fact CH74/- only arrived on Monday 05 February, and thus far has only attained 475km/s. Any glancing CME would therefore most likely be delayed until on or after midweek UTC.

With the above uncertainties mainly affecting the second half of the coming UTC working week, fast winds from CH74/- and perhaps CH75/- will characterise Tuesday (UTC) at least, with Earth now experiencing a negative high speed stream. Solar winds should remain Slightly Elevated or perhaps Elevated until Thursday 08 February when they are forecast to gradually decline as coronal hole effects wane.

All considered, Unsettled to Active geomagnetic conditions, with a slight chance of G1 Minor Storm intervals should reduce to predominantly Quiet levels from midweek UTC. However, as stated above there is a degree of uncertainty given passing transients through the second half of the UTC week.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	5	5	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Nil, but low confidence in this assertion for glancing arrivals from midweek UTC.

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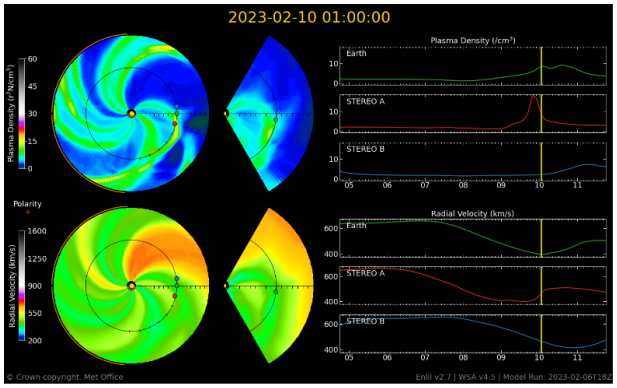
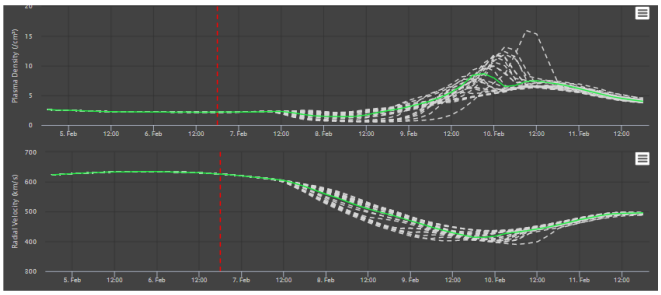
Figure 2: Latest MOSWOC Enlil run (06/1800UTC), showing a consistent divergence from the deterministic in many ensemble members from later in the current UTC day. As with previous guidance, Enlil's recent modelling of a 600-650km/s fast wind from 04 February to date will likely mean that CMEs will reach 1AU sooner than in reality, and any glancing incidence is therefore more likely to be a feature from midweek UTC – if present. The below simulation is paused around the time of the most likely of these minor passes, i.e. a glance on or around the turn of the UTC day 09 into 10 February (coinciding with some the largest MOSWOC Enlil ensemble members' peaks).





Radio Blackouts - X-Ray Flares:

The current solar disc consists of up to nine sunspot groups, with the focus of development shifting from the southwest to the northeastern quadrants in the past 24 hours in a resurgent solar disc. Despite the presence of numerous growing bipolar groups, Low solar activity has so far prevailed, although this looks more fragile than at any time in the past week given the increased cadence of C-class flares as Monday progressed.

In terms of the balance of sunspot groups on the front side, the southwest quadrant is felt to offer a decreasing contribution to risks, regardless of departing groups, with the focus instead shifting to the east and the possible arrival yet more Carrington locations for spot groups - namely Ex-3188; 3190; 3191; 3192; 3194 and 3195, which are all due inside 48 hours. Therefore there is an increasing chance through the period of moderate solar activity and M-class flares, but probably saturating by midweek UTC (barring development).

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**R1-R2 M Class**	No	25	30	30	30
Very Active	**R3 to R5 X Class**	No	1	1	1	1

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Figure 3: Helioviewer.org-generated difference image (HMIIF-derived) of footprint of active regions at 05/2100UTC (white) versus 06/2100UTC (black) – note the resurgent northeastern quadrant in particular.

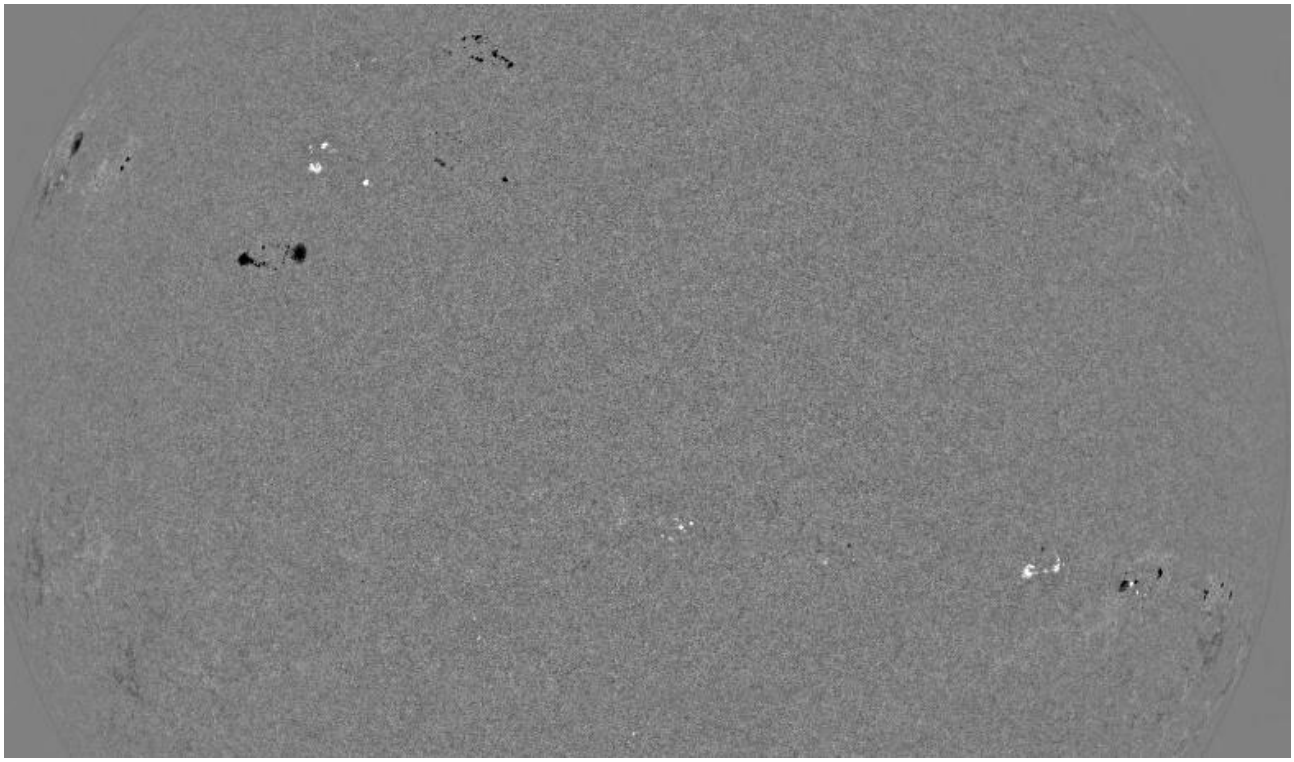
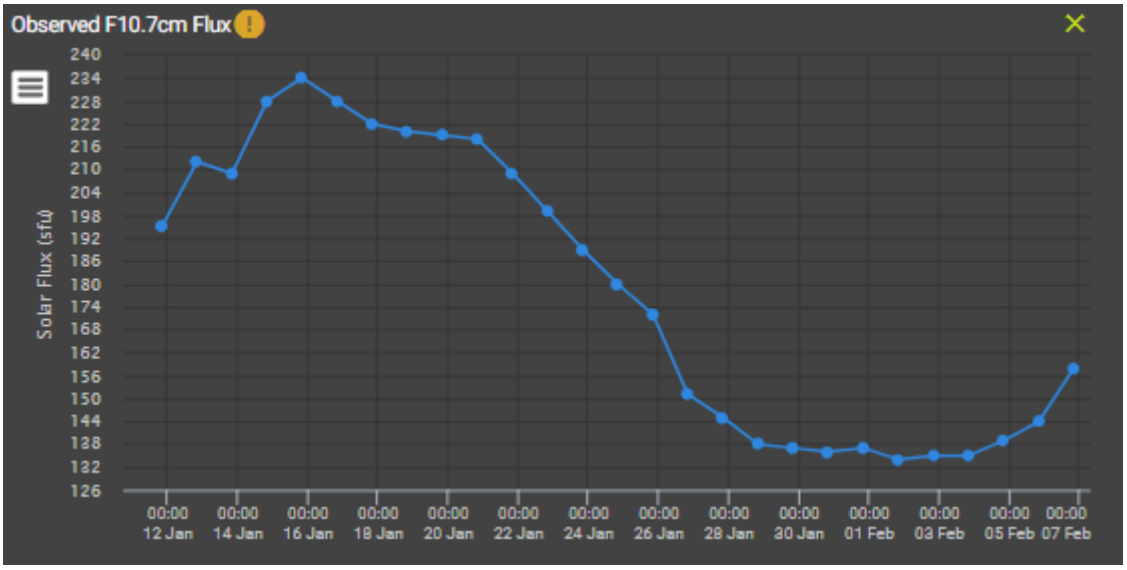


Figure 4: 27-day 10.7cm Penticton flux, showing that the Sun is potentially going into another sunspot number growth phase after a something of a lull seen in the past ten days or so.



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Solar Radiation Storms - (High Energy Protons):

High energy (greater than 10MeV) proton flux as observed by GOES16 is at Background levels, and is currently expected to remain as such throughout the period given the absence of significant flaring and complex western solar hemisphere sunspot groups.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	1	1	1	1
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) as observed by GOES16 is currently at Normal Background levels, and is expected to remain so in the near-term. An eventual increase to Moderate and perhaps High levels is likely from midweek UTC in a response to the current coronal hole fast wind environment, with an eventual Chance of fluence exceeding Active.

MOSWOC REFM is rendered less useful for this forecast period as the solar wind enhancement is both non-persistent and potentially polluted by minor transient activity later this working week.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	10	30	30	30
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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